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I, KAY WARD, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ1740 for a patent by TOMASZ RUDAS filed on 20 July 1999.

I further certify that the above application is now proceeding in the name of ORGANIC RESOURCE TECHNOLOGIES PTY LTD pursuant to the provisions of Section 113 of the Patents Act 1990.

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COMMONWEALTH OF AUSTRALIA
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Twenty-sixth day of July 2000

K Ward

KAY WARD
TEAM LEADER EXAMINATION
SUPPORT AND SALES

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APPLICANT: ~~TOMASZ RUDAS~~
Organic Resource Technologies Pty Ltd

NUMBER:

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FILED:

AUSTRALIA

THE PATENTS ACT 1990

PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

"ANAEROBIC DIGESTION AND AEROBIC COMPOSTING OF ORGANIC WASTE MATERIAL"

The present invention is described in the following statement:

TITLE

"ANAEROBIC DIGESTION AND AEROBIC COMPOSTING OF ORGANIC WASTE MATERIAL"

The present invention relates to the anaerobic digestion and aerobic composting of organic waste material.

It is well known that degradation of solid organic waste material to a bioactive, stabilised end product such as compost for gardens, can be achieved by treating the solid organic waste material under either anaerobic or aerobic conditions, in which anaerobic or aerobic microorganisms respectively, metabolise the waste material to the end product.

Aerobic decomposition of solid organic waste takes place in the presence of oxygen. Energy produced during aerobic decomposition is released as heat, the temperature of the reaction substrate frequently rising to 75°C under ambient conditions. The resulting solid end product is generally rich in nitrates which is a readily bioavailable source of nitrogen for plants. Thus the bio-available resulting end product is an excellent fertilising material for gardens and has commercial value as such.

Anaerobic digestion of solid organic waste takes place in the absence of oxygen. Typically, the solid organic waste must be heated to a mesophilic or thermophilic temperature range in order for anaerobic microbial metabolism to be optimised. Energy produced during anaerobic digestion is conserved as methane gas. The resulting solid end product is generally rich in ammonium salts.

Ammonium salts are not readily bio-available for uptake by plants. It is known, therefore, to treat residues, resulting from anaerobic digestion, with conditions under which aerobic

decomposition will proceed. Thus, the material is converted to one rich in nitrates and which is of commercial value.

Systems have been designed to cater discretely for each type of degradation, but some have been designed to combine both anaerobic and aerobic decomposition processes.

German Patent Number 4440750 relates to an apparatus for raw material and energy recovery from biomass which has an anaerobic fermentation unit, an aerobic composting unit, a gasification unit and a power generating plant. The apparatus utilises byproducts from the anaerobic fermentation unit and the aerobic composting unit to work synergistically to provide reduced amounts of residues and to improve raw material and energy production.

International Patent Application Number WO 94/24071 discloses treatment of organic bioresidues especially from municipal and industrial wastes, including raw and/or cooked food residues, agricultural wastes and/or plant vegetable components. The bioresidues are first homogenised, fermented in an anaerobic reactor wherein the resulting biogas is removed, and then the residual solids are transferred to a composting chamber.

These and other similar systems provide discrete and separate chambers or vessels for aerobic decomposition and anaerobic digestion, respectively. Material which has undergone one set of conditions is transferred to a separate location to undergo a secondary processing phase. The transfer of material from one location to another is not efficient in terms of time, costs and labour.

The present invention seeks to overcome, at least in part, some of the aforementioned disadvantages.

In accordance with a first aspect of the present invention there is provided an organic waste material treatment process for use in a discrete vessel comprising the steps of:

a) displacing air in the vessel and contents thereof to create conditions suitable for anaerobic digestion of the contents to proceed;

b) anaerobically digesting the contents of the vessel;

c) separating gaseous byproducts from residues resulting from step b);

d) removing at least a portion of the water from the vessel;

e) aerating residues in the vessel to create conditions suitable for aerobic composting of the residues to proceed;

f) aerobically composting the contents of the vessel; and

g) recovering compost resulting from step f) from the vessel.

In accordance with a second aspect of the present invention there is provided an organic waste material treatment process for use in a plurality of interconnected discrete vessels comprising the steps of:

a) displacing air in the vessel and contents thereof to create conditions suitable for anaerobic digestion of the contents to proceed;

b) anaerobically digesting the contents of the vessel;

c) separating gaseous byproducts from residues resulting from step b);

d) removing at least a portion of the water from the vessel;

e) aerating residues in the vessel to create conditions suitable for aerobic composting of the residues to proceed;

f) aerobically composting the contents of the vessel; and

g) recovering compost resulting from step f) from the vessel.

In accordance with a third aspect of the present invention there is provided a vessel for anaerobic digestion and aerobic composting of organic waste material including a means for receiving organic waste material, first feed means for supplying water to the vessel and second feed means for supplying air to the vessel, wherein the first and second feed means is arranged to supply water and air to the organic waste material evenly; said vessel being devoid of any internal agitation means.

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic diagram of an apparatus, arranged in use, to house organic waste material and to facilitate therein a sequential decomposition process comprising an anaerobic digestion stage and an aerobic composition stage, in accordance with the present invention; and

Figure 2 is a schematic diagram of a plurality of vessels shown in Figure 1, interconnected by a recirculation means, wherein each vessel is arranged in use to house organic waste material and to facilitate a sequential decomposition process therein, and the recirculation means is arranged in use to recirculate byproducts from each vessel to an adjoining vessel in accordance with the present invention.

In Figure 1 of the accompanying drawings there is shown an apparatus 10, arranged in use, to house organic waste material and to facilitate a sequential decomposition process therein.

The apparatus 10 includes an air tight vessel 20, arranged, in use, to house organic waste material. Preferably, the vessel 20 is constructed from a rigid, chemically inert material with good structural integrity such as steel or concrete.

An uppermost wall 22 of the vessel 20 is provided with a receival hatch 24 which is arranged in use to remain in an open position when organic waste material is loaded or unloaded from the vessel 20, and which is arranged in use to remain in a closed position when the organic waste material is undergoing the sequential decomposition process therein.

The organic waste material may be loaded into the vessel 20 by an auger loader 30 and a conveyor belt 40 as shown in Figure 1. It will be appreciated, however, that any convenient conveying and loading system may be used to load the vessel 20 with organic waste material.

The vessel 20 is also provided with an extraction hatch 27 which is disposed in a wall 21 of the vessel 20. The extraction hatch 27 is arranged in use to remain in an open position when an end product of the sequential decomposition process is unloaded from the vessel. The extraction hatch 27 is arranged in use to remain in a closed position during the sequential decomposition process.

The vessel 20 is provided with a plurality of feeder lines 26 which are arranged, in use, to deliver air or water to the vessel 20. Under negative pressure, feeder lines 26 are also arranged to drain the vessel 20 of excess water. The feeder lines 26 are disposed in at least one wall 21 of the vessel 20 such that the water or the air is evenly distributed in the organic waste material housed by the vessel 20. The even distribution of water or air eliminates the necessity for an agitation means within the vessel 20 to homogenise conditions therein.

The feeder lines 26 are connected with a control line 28 which is arranged to control the flow and distribution of water and air to and from the vessel 20.

The uppermost wall 22 of the vessel 20 is also provided with a gas extraction line 50 and a first valve 52. The gas extraction line 50 interconnects the vessel 20 and a de-watering tank 60. The gas extraction line 50 is arranged, in use, to extract gases generated in the interior of the vessel 20 during an anaerobic digestion stage of the sequential decomposition process, or to extract air from the head space of the vessel 20 during the aerobic composting stage of the sequential decomposition process.

The de-watering tank 60 is arranged, in use, to remove water from the extracted gases.

The de-watering tank 60 is provided with a first and a second recirculation lines 62 and 64, wherein the first recirculation line 62 is arranged in use to recirculate gas, from which water has been removed, through the apparatus 10, and the second recirculation line 64 is arranged in use to recirculate water, removed from the gas, through the apparatus 10.

The first recirculation line 62 is provided with a first pump 61 which is arranged to facilitate recirculation of gas through the apparatus 10. Air from an external source may also be pumped into the first recirculation line 62 via a first port 65.

The second recirculation line 64 is provided with a second pump 63 which is arranged to facilitate recirculation of water though the apparatus 10. Water from an external source may also be pumped into the second recirculation line 64 via a second port 66. The second port 66 is also arranged to receive biological or chemical additives, such as a bacterial inoculum, enzymes and pH buffers.

The first and second recirculation lines 62, 64 are interconnected with the vessel 20 by the control line 28 and the feeder lines 26.

The apparatus 10 is provided with a biofilter 70 which is interconnected with the first recirculation line 62 by an exit line 72. The biofilter 70 is arranged in use to scrub the

recirculating air of odorous emissions resulting from the first and second composting stages of the sequential composting process prior to exhaustion of the scrubbed recirculating air into the atmosphere.

The apparatus 10 is also provided with a gas storage tank 80 which is interconnected with the first recirculation line 62 by a first storage line 82. The gas storage tank 80 is arranged in use to receive methane gas generated during the anaerobic digestion stage of the sequential decomposition process. It will be understood that the received methane gas will have been treated in the de-watering tank 60 prior to storage in the gas storage tank 80.

The gas storage tank 80 is interconnected with a generator 85 by a generator line 84. The generator 85 is arranged to convert the methane gas to electrical power, wherein the electrical power may be distributed to other components of the apparatus 10.

Alternatively, any excess electrical power generated by the generator 85 could be distributed to an external power grid.

As shown in Figure 1, the apparatus 10 also includes a water heater tank 90. The water heater tank 90 is interconnected with the de-watering tank 60 by the second recirculation line 64. The water heater tank 90 is arranged to receive water from the de-watering tank 60 and from the port 66 via the second recirculation line 64. The water heater tank 90 is also interconnected with the gas storage tank 80 by a first delivery line 87. The water heater tank 90 is provided with means to convert the methane gas, received from the first delivery line 87, to heat in order to control the temperature of the water in the water heater tank 90.

It will be understood that water in the water heater tank 90 is maintained at a temperature of 15°C to 75°C. The stored water is arranged in use to be recirculated through the apparatus 10 via the second recirculation line 64, the control line 28 and the feeder lines 26 into the vessel 20 at commencement of anaerobic digestion stage of the sequential decomposting process. Delivery of water heated to a temperature range at which anaerobic microbial activity is optimised assists the anaerobic digestion stage of the sequential decomposting process.

As shown in Figure 1, the apparatus 10 also includes a water storage tank 92. The water storage tank 92 is interconnected to the second recirculation line 64. The water storage tank 92 is arranged to receive and store water extracted from the vessel 10 after completion of the anaerobic digestion stage of the sequential decomposition process.

The apparatus 10 is also provided with a heat exchange means 95 which is interconnected with the gas extraction line 50. The heat exchange means 95 is arranged in use to utilise energy from hot air extracted during the of aerobic composting stage. The energy from the extracted hot air is used to heat water stored in the water heater tank 90. It will be appreciated that the extracted hot air may also be recirculated through the apparatus 10 via the first recirculation line 62, the control line 28 and the feeder lines 26 into the vessel 20 before the commencement of the anaerobic digestion stage in order to heat the organic waste material therein. Preheating the organic waste material to a temperature range of between 15°C and 75°C at which anaerobic microbial activity is optimised assists the anaerobic digestion stage of the sequential decomposition process. It will be understood

that the heat exchange means 95 operates most efficiently when included in a plant where a plurality of vessels 10 are configured in a sequential batch configuration.

In Figure 2 of the accompanying drawings there is shown an apparatus 100 including a plurality of vessels 20 as described in Figure 1, interconnected with one another by the first and second recirculation lines 62 and 64.

In addition to the functions of the first recirculation line 62 previously described in relation to Figure 1, the first recirculation line 62 is also arranged to facilitate recirculation of gas extracted from one vessel 20 to the control line 28 and feeder lines 26 of another vessel 20. For example, hot air extracted from one vessel 20 after completion of the aerobic composting stage can be recirculated to another vessel 20 which may require aeration for the aerobic composting stage. Alternatively, the organic waste material housed by another vessel 20 may be heated by the recirculated hot air before commencement of the anaerobic digestion stage in that vessel 20.

In addition to the functions of the second recirculation line 64 previously described in relation to Figure 1, the second recirculation line 64 is arranged to facilitate recirculation of water removed from one vessel 20 to the control line 28 and feeder lines of another vessel 20. For example, water removed from one vessel 20 after completion of the anaerobic digestion stage can be recirculated to another vessel 20 which may require an increased water content to commence the anaerobic digestion stage.

It will be appreciated that the contents of each vessel may be at varying stages of the sequential decomposition process. Preferably, each vessel is configured to form a sequential batch to facilitate continuous operation of the sequential decomposition process.

A multiple vessel system is configured such that one vessel is filled with organic waste material while another is being emptied, the remaining vessels in the multiple vessel system being arranged to be at various stages of the sequential decomposition process.

It will also be appreciated that additional vessels 20 may be interconnected to the apparatus 100 by the first and second recirculation lines 62 and 64 to increase processing volumes of the apparatus.

As shown in Figure 2, there is provided a gas extraction line 52 for air removed from the aerobic composting stage, and an additional gas extraction line 52a for the separation of gases such as methane and carbon dioxide, which are generated during the anaerobic digestion stage.

The sequential decomposition process of organic waste material will now be described with reference to the apparatus 10 as shown in Figure 1 and the apparatus 100 as shown in Figure 2.

The sequential decomposition process of organic waste material is a two stage process including an anaerobic digestion stage followed by an aerobic composting stage. Preferably, the organic waste material undergoes a preliminary conditioning stage before commencement of the anaerobic digestion stage. The purpose of the preliminary conditioning stage is to raise the temperature of the contents of the vessel 20 to a temperature range of 15°C - 75°C. Once the contents of the vessel 20 have attained this temperature, conditions within the vessel 20 are then created in which the anaerobic digestion stage commences. The present invention seeks to achieve this purpose by providing a preliminary conditioning stage which does not rely on the provision of a fuel driven heating means to raise the temperature of the contents within the vessel 20. heating

Preferably, the preliminary conditioning stage comprises creating conditions under which the contents of the vessel 20 undergoes aerobic composting. Heat generated by the aerobic composting of the contents of the vessel 20 raises the ambient temperature thereof to 15°C - 75°C at which point the conditions within the vessel 20 are changed by an operator such that the anaerobic digestion stage commences.

It will be understood that other suitable means to raise the temperature of the contents of the vessel 20 may be used as a preliminary conditioning stage. For example, heated water from a convenient accessible geothermal source may be pumped into the contents of the vessel 20 to raise the temperature therein to the desired range for commencement of the anaerobic digestion stage.

The organic waste material is typically sized and mixed to effect a substantially homogenous mixture. It is understood that organic waste material refers to solid organic waste material, comprising vegetable matter; household and municipal organic waste, including cellulosic material such as waste paper; industrial organic waste; and agricultural organic waste, for example animal manures. Consistency of the material is preferably optimised for optimum water flow through the contents in the vessel 20 during the anaerobic digestion stage, and optimum air flow during the aerobic composting stage.

The receival hatch 24 of the vessel 20 is opened, and the auger loader 30 and conveyor belt 40 deliver the homogenised waste material into the vessel 20 until the vessel 20 is substantially full. The receival hatch 24 is then closed to seal the vessel 20.

The preliminary conditioning stage comprises an aerobic composting stage including:

1) adjusting the moisture content of the waste material to 40-60% w/w;

2) pumping air into the vessel; and

3) decomposition of the waste material by aerobic bacteria.

Water from an external source at the second port 66 is pumped by the second pump 63 through the second recirculation line 64 and into the vessel 20 via the control line 28 and the feeder lines 26. The feeder lines 26 evenly distribute the water through the organic waste material such that the moisture content of the waste material ranges from 40-60% w/w throughout the vessel 20. Alternatively, water may be sourced from the water heater tank 90, the water storage tank 92, or excess water recirculated from another vessel 20.

Air from an external source at the first port 65 is then pumped by the first pump 61 through the first recirculation line 62 of the apparatus 10 and into the vessel 20 via the control line 28 and the feeder lines 26. The feeder lines 26 evenly distribute the air through the organic waste material such that the organic waste material is substantially evenly aerated.

It will be appreciated that initially during the aerobic composting stage air is optionally extracted from the headspace in the vessel 20 between the organic waste material and the uppermost wall 22 of the vessel 20, via the gas extraction line 50. The extracted air may optionally have water removed therefrom in the de-watering tank 60 before the air is pumped through the first recirculation line 62 by the first pump 61 back into the vessel 20.

Alternatively, air extracted by the means described above may be sourced from another vessel 20.

Under the conditions described above, indigenous aerobic bacteria present in the organic waste material begin to metabolise and break down the organic waste material. The preliminary stage operates in a temperature range of 15°C to 75°C for a period between 1

to 28 days. It will also be appreciated that when optimum temperature conditions for the anaerobic digestion stage process are established the vessel 20 will be sealed.

Oxygen levels will eventually be depleted in the sealed vessel 20 by action of the aerobic bacteria therein. When the oxygen levels in the vessel 20 are sufficiently depleted, the anaerobic digestion stage of the sequential decomposition process commences.

The anaerobic digestion stage includes:

1) adjusting the moisture content of the waste material to 50-95% w/w; and

2) digestion of the waste material by anaerobic bacteria.

Water from an external source at the second port 66 is pumped by the second pump 63 through the second recirculation line 64 and into the vessel 20 via the control line 28 and the feeder lines 26. The feeder lines 26 evenly distribute the water through the organic waste material such that the moisture content of the waste material ranges from 50-95% w/w throughout the vessel 20. It will be appreciated that the water from the external source may have been mixed with a bio-sludge to act as an anaerobic bacterial inoculum. It will also be appreciated that heated water from the de-watering tank 60 may be pumped through the second recirculation line 64 and into the vessel 20 via the control line 28 and the feeder lines 26. Alternatively, water removed from another vessel 20 which has undergone the anaerobic digestion process may be recirculated by the second recirculation line 64 into the present vessel 20. In this way, process water from one anaerobic digestion can be used to inoculate the next anaerobic process in a multiple vessel system.

The anaerobic digestion process operates in a mesophilic to thermophilic temperature range between 25°C -75°C for a period between 4 to 20 days.

Methane and carbon dioxide gases which are generated during the anaerobic digestion process are extracted under pressure through the gas extraction line 50, and recirculated to the de-watering tank 60 where water is removed from the extracted gases. The gases are then recirculated through the first recirculation line 62 to the gas storage tank 80 via the first storage line 82. The gas may then be converted to electrical power by the generator 85, or alternatively, used to heat water stored in the water heater tank 90.

The water which is removed from the extracted gases by the de-watering tank 60 is then recirculated to the heater tank 90 by the second recirculation line 64. The water may be heated in the water heater tank 90. The heated water may also be recirculated by the second recirculation line 64, the control line 28 and the feeder lines 26 back into the vessel 20 for a subsequent anaerobic digestion process.

Following completion of the anaerobic digestion process conditions within the vessel 20 are altered such that the aerobic composting stage may commence.

Excess water is removed from the vessel 20 via the feeder lines 26 and the control line 28, under gravity drainage combined with application of a negative pressure to draw excess water into the second recirculation line 64. Thus, the moisture content of the contents within the vessel 20 is adjusted to 40 to 60% w/w. It will be appreciated that the moisture content can also be lowered to the desired range by pumping warm air sourced from another vessel 20, in a multiple vessel system undergoing aerobic composting through the control line 28 and the feeder lines 26 into the vessel 20. The excess water is recirculated into the water storage tank 92. Alternatively, the excess water may be recirculated by the second recirculation line 64 into another vessel in a multiple vessel system whose contents are about to undergo the anaerobic digestion stage.

The contents of the vessel 20 are aerated by pumping air through the control line 28 and the feeder lines 26 into the vessel 20. It will be appreciated that the conditions for the aerobic composting stage which follows the anaerobic digestion stage are the same as for the aerobic composting stage of the preliminary conditioning stage described previously. Adjustment to the operating parameters may be made by dosing the vessel contents through the second port 66 as previously described.

It will be appreciated that heat generated from the aerobic composting stage may be used to facilitate the formation of mesophilic to thermophilic conditions for an anaerobic digestion stage or an aerobic composition stage occurring in another vessel.

Upon completion of the aerobic composting stage, the resulting material will be deposited from the vessel 20 through the extraction hatch 27, loaded and packed for sale.

Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention.

DATED THIS 16TH DAY OF JULY 1999.
Organic Resource Technologies Pty Ltd

~~TOMASZ RUDAS~~
By his Patent Attorneys
LORD & COMPANY
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AUSTRALIAN PATENT OFFICE SEC 113

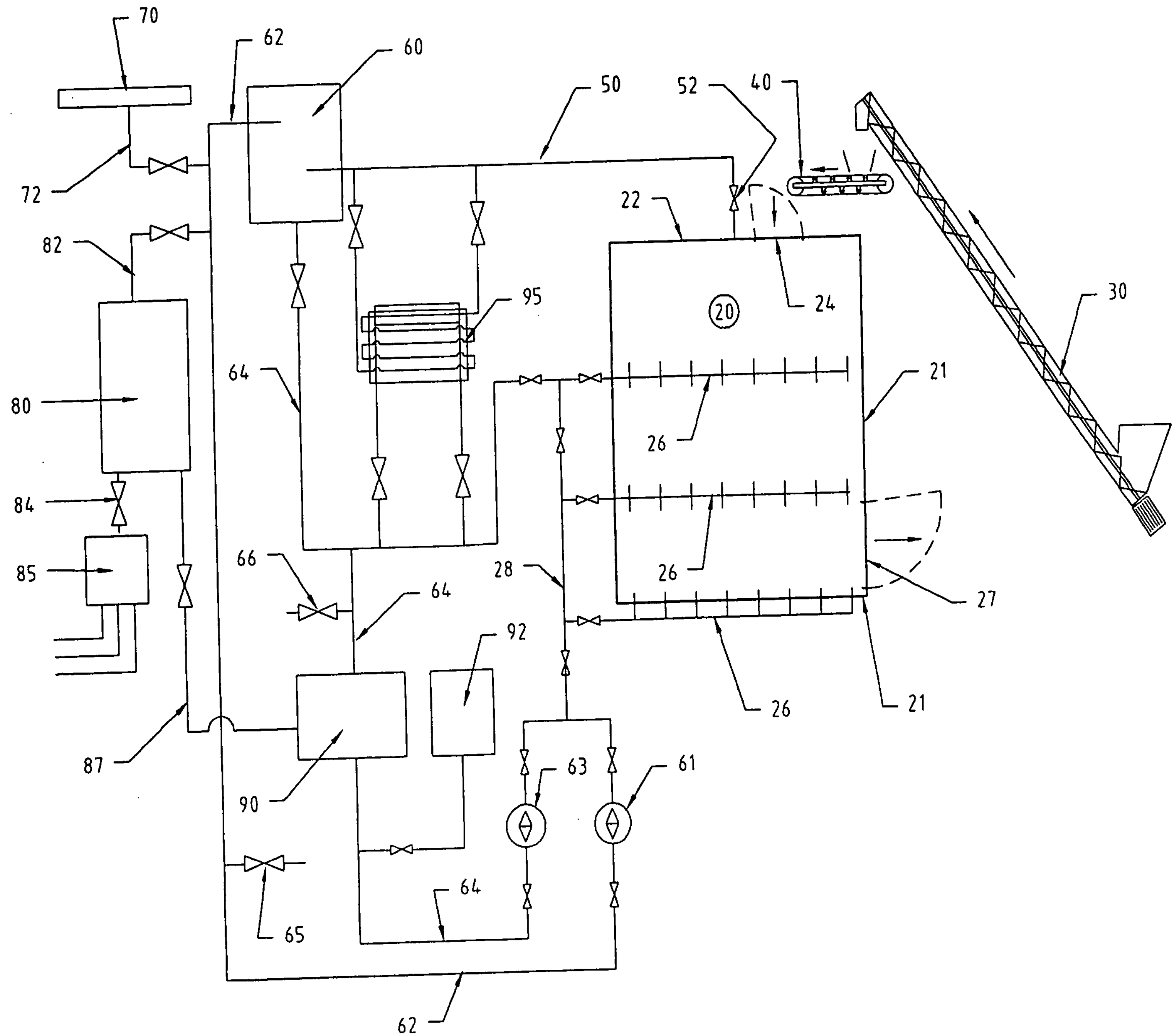

Figure 1 - APPARATUS 10

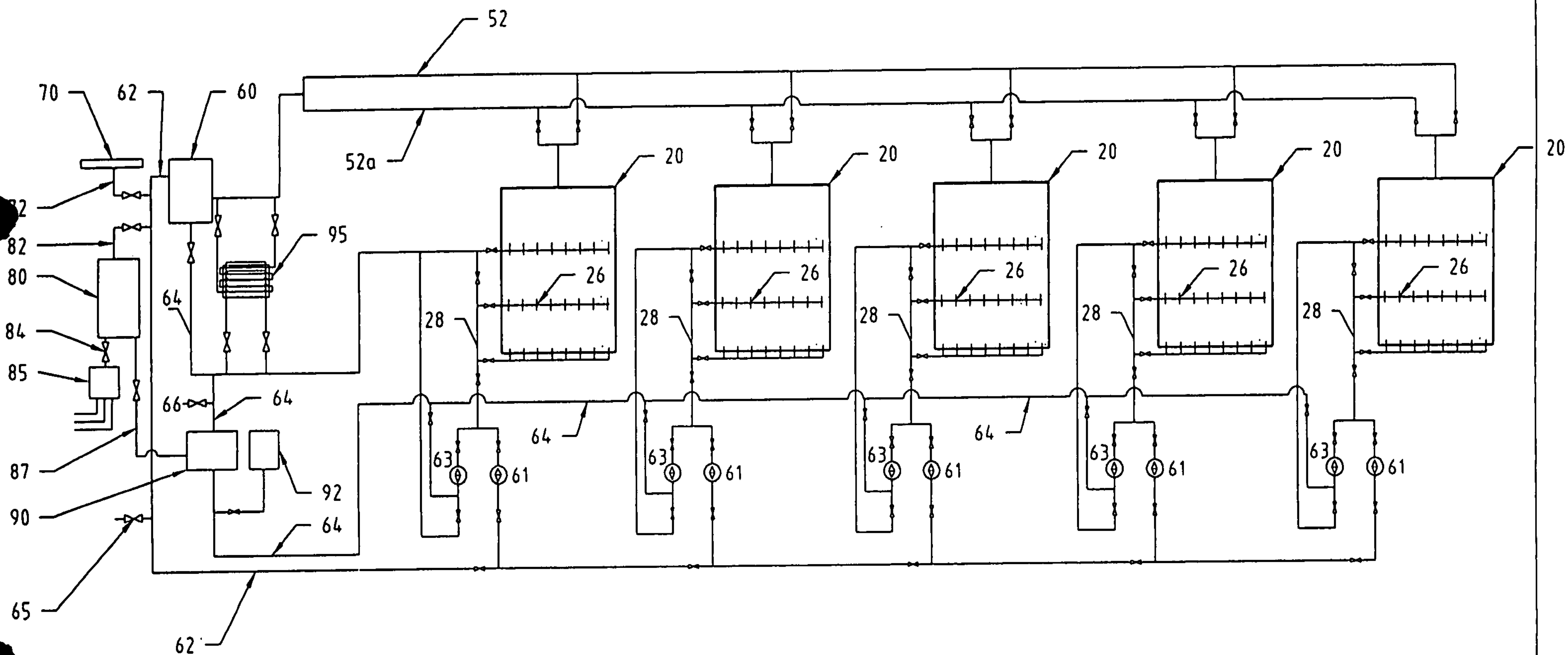

Figure 2 - APPARATUS 100